SIMULATING FOREST FIRE AND FOREST SUCCESSION AT BRYCE CANYON NATIONAL PARK

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ABSTRACT

Environmental characteristics control the range of possible vegetation composition and structure at a given site by restricting the set of species that can establish and persist to those with compatible physiology and life histories. Because environmental variability is spatial as well as temporal, vegetation composition and structure exhibit complex spatial patterns reflecting constraints imposed by the environment. The interaction of disturbance, dispersal, and successional dynamics determines the actual vegetation composition and structure at any given time, within the range of possible vegetation at a given site. Characteristics of species, and of individuals within species, determine the course of successional dynamics from a set of initial conditions. Stochastic components of dispersal and subsequent disturbance limit or control the future vegetation development. Accordingly, vegetation composition and structure at a given site are highly dynamic processes. Because disturbance regimes and dispersal are also spatial processes, vegetation exhibits more spatial patterning than would be expected by environmental constraint alone.

The vital attributes/fuzzy systems model (VAFS/LANDSIM) is designed to simulate landscape-to-regional vegetation composition and structure by: (1) employing environmental constraints on the set of species that can establish at a given site; (2) employing spatially-explicit dispersal and propagule availability as a constraint on species establishment probabilities; (3) simulating vegetation successional dynamics as a function of species' establishment requirements, competitive ability, and longevity; and (4) by simulating spatially-explicit disturbance events and vegetation response as a function of disturbance type, intensity, and the composition and structure of the vegetation at the time of disturbance. The VAFS/LANDSIM model was designed as a general simulation tool for studying vegetation distribution and dynamics in environments subject to recurrent disturbance, and is thus suitable for answering a broad range of theoretical questions about vegetation dynamics as well as applied questions about specific ecosystems or landscapes. It is easy to parameterize, efficient with computer resources, and easily integrated with geographic information systems to facilitate simulating real landscapes as well as presenting complex spatially explicit results.

The VAFS/LANDSIM model is used in this paper to simulate historic and possible future vegetation composition and structure trajectories for Bryce Canyon National Park, Utah. The historic vegetation of Bryce Canyon was reconstructed from relocated historic photographs and vegetation age-structure analysis and includes a vegetation gradient from sagebrush and pinyon-juniper woodlands to mixed-conifer forests, with estimated wildfire return intervals from a few decades to centuries. Simulations of changes in the natural fire return intervals demonstrate significant changes in vegetation composition and structure at the stand level, as well as significant changes in landscape vegetation diversity and patchiness.